reasonable accuracy.[2] It is hard to believe that the Commission intended such an irrational outcome.

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[2] One might ask if the Commission considered the prospect of interference between co-channel AVM systems in the same city. The Hazeltine Petition for Rulemaking (RM-1734) requested use of two ten-MHz subbands in the 902-928 MHz ISM band, and Hazeltine observed that these two subbands provided sufficient spectrum for two pulse systems in the same areas:

> The system which Hazeltine proposes to provide for AVM Information Service is based on pulse transmissions. Consequently, the bandwidth required by the system is 10 MHz. However, one 10 MHz channel will be sufficient to serve the vehicle monitoring information needs of tens of thousands of vehicles in a large population center. Furthermore, there is sufficient bandwidth in the proposed allocation to permit two pulse systems in the same area, each using 10 MHz of bandwidth, with 6 MHz of separation (the ISM mid-band) between them. It is unlikely that the market would support more than two high-capacity services in the same area. Similarly, since transmissions at the frequencies under discussion are line-of-sight, there is small likelihood of interference between systems operating in separate large population centers. But in the event of two independent systems operating in centers close enough so that interference by line-of-sight transmission is possible, two different 10 MHz systems could operate without mutual interference.

Hazeltine Corporation Petition for Rulemaking, RM 1734, filed Dec. 24, 1970 at 29-30.

The Commission's Notice of Proposed Rulemaking in RM 1734 explicitly stated that the Hazeltine proposal was a central issue. See 35 FCC 2d 692, 694 (1972). Two years later, the Commission in adopting the interim rules explicitly noted its agreement with Hazeltine's analysis.

> ... Accordingly, we are providing for wideband AVM operation in the frequency band 904-912 MHz and 918-926 MHz. This reduces the bandwidth for the pulse-ranging techniques from 10 MHz to 8 MHz, but we are satisfied that this is adequate for this operational method, and under this approach, two separate wideband AVM systems may be accommodated in each market.

Report and Order, Docket 18302, July 31, 1974 at 10 (emphasis added).

12. Any system for channel sharing requires common knowledge and shared technology. It is reasonably easy for two paging systems to share a channel;[3] it would be very hard for a paging system and a broadcaster to share a channel. But, the 1974 interim rules imposed no technological requirement to assist sharing and nowhere seem to contemplate sharing. Indeed, one passage in the Report and Order adopting those rules explicitly recognized a limit of two WBPR AVM systems in any single service area. The flexible rules are consistent with the expectation of one service provider in each band segment and are not consistent with a sharing obligation ungoverned by any specific rules for such sharing.

13. Sharing would require rules that would delineate the obligations of each of the co-channel system operators in a service area. Such rules should establish protocols for detecting the presence of transmissions of other systems and avoiding interference. For example, the Commission's rules governing the air-to-ground telephone service (Part 22,

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[3] However, the Commission has recently proposed to allow exclusive use of private carrier paging channels. See the Notice of Proposed Rule Making. PR 93-35, adopted February 18, 1993. In that Notice the Commission stated

> As paging channels are occupied by an increasing number of competing service providers, the sharing of frequencies, while technically feasible, threatens to discourage optimally efficient use. Paging operators on a common frequency must invest in monitoring or interconnection equipment.... According to some PCP operators, frequency sharing has inhibited the development of wide-area paging systems that rely on high-speed technologies...
>
> * * * *
>
> ... Granting qualified licensees exclusive rights to a channel will eliminate the inefficiencies in sharing channels. . . Thus, licensees will have greater incentive to invest in technology and to develop higher-capacity paging systems.

NPRM PR 93-35, ¶¶ 5 at 15, 16.

Apparently, even where sharing is relatively easy to accommodate technically, unlike the case in AVM, there can still be compelling policy arguments against it.

Subpart M) contain an extensive discussion of the protocols governing spectrum sharing (see § 22.1115) in that service.

14. The air-to-ground rules require each licensee to monitor a channel and insure that it is vacant before transmitting on that channel. Such a carrier-sense multiple access protocol[4] can be expected to work fairly well for systems carrying telephone communications on parallel FDM channels. (If we assume that an air-to-ground telephone conversation lasts two minutes and that the monitoring base station is 200 miles from the transmitter, then there is a period at the beginning of a conversation of about one thousandth of a second (one part in 120,000) where the monitoring station cannot

15. The prospect of off-air monitoring is made more difficult if a system design requires that mobile units listen before transmitting. Such a requirement implies that mobile units have receivers capable of quickly detecting the presence of spread-spectrum signals using a variety of spreading and modulation techniques. But, mobile units with such capabilities would be significantly more expensive and might also be larger than they would be without such capabilities. This increased cost and size would limit the market acceptance of this service.

16. Another approach would be to eliminate the off-air monitoring altogether and use dedicated connections between the network control centers of the multiple AVM systems. While dedicated connections between paging system operators frequently facilitate sharing in that service, such connections cannot be counted on in a service with the technical flexibility of the AVM service. For a specific example, see the discussion of time-division sharing below.

C. Sharing On a Time-Division Basis

17. While a time-division approach to sharing between two WBPR AVM systems sounds simple, there are numerous practical problems in implementing time-division sharing between WBPR AVM systems.[5] The readily apparent problems include

- the time scales of the two systems may not mesh,
- time-division cannot easily accommodate asynchronous transmission from mobile units,
- maintaining system synchronization is difficult and reestablishing synchronization does not fit well into a time-division world, and
- spectrum efficiency suffers because more overhead transmissions are required.

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[5] Clearly, the problems can be expected to be more extreme between two quite different systems than between two identical systems, but even identical systems may have severe problems sharing.

18. Modern communication systems operate under stored program control. These programs contain multiple timers that control the initiation and termination of various events. For example, if you leave a telephone off the hook too long, the switch removes dial tone and puts a loud beeping sound on the line. AVM systems have minimum transmission time requirements and have maximum inervals during which they can maintain system integrity and synchronization without transmitting. It is quite possible to imagine two WBPR AVM systems with incompatible time constants. If one system's requirement for a minimum contiguous block of time exceeds another system's maximum time without transmissions, then the systems could not share a band segment. Time-division sharing would be impossible without modifying one or both systems (assuming such modifications were feasible or economic).

19. The time-division model does not appear to accommodate asynchronous transmissions from mobile units. Asynchronous transmissions from mobile units can serve many public interest benefits[6] but do not fit with time-division protocol.

20. Maintaining system synchronization and transmitting other overhead communications becomes difficult and wastes spectrum in a time-division scenario. AVM systems need to use some of their channel capacity in overhead transmissions that, among other things, maintain system synchronization. Using arbitrary numbers, assume that an AVM system uses 25 percent of its transmission capacity for synchronization and other overhead tasks. If such a system were to share with two other systems, it would need to use 75 percent (25/33.333) of its allotted capacity just for these system functions. If it had to share with four systems, it would have to use 100 percent of its capacity for such overhead functions. In this type of environment where there is a significant overhead requirement, there are two consequences. First, it is impossible to have open entry in such an environment. Second, if regulators intervene and reduce the overhead

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[6] As discussed earlier, asynchronous mobile transmissions may lower the cost of mobile units -- this could be particularly cost effective for mobile units that require very infrequent location updates. Asynchronous mobile transmissions also add to system security and reliability.

time made available to each firm, system performance suffers. Furthermore, systems occasionally lose synchronization and must reestablish such synchronization. An unsynchronized system could create considerable interference into a co-channel system operating in the same during the period it was re-establishing synchronization.

21. If the interim rules had provisions governing time division between operators, then system designers could have taken these rules into account when designing their systems. Some of the problems discussed above, e.g., the difficulty of accommodating asynchronous mobile units, would remain, but system designers could have avoided other problems. However, the rules offer no such guidance. Time-division multiplexing is a simple concept that might appear to offer an easy route to AVM sharing. Examination of the practical problems of implementing time-division sharing show that it will necessarily reduce service and may be quite difficult to accommodate in a practical environment.

D. Miscellaneous Observations

21. In its Opposition, Pinpoint repeats a claim that Pinpoint has raised before -- "... doubling of occupied bandwidth increases the position fixing throughout by a factor of 8..." (Opposition at 13.)

22. I am not aware of any theory that supports this claim. The widely used Cramér-Rao bound can be interpreted to yield such a prediction if misused -- in particular if one neglects to note that doubling the bandwidth also increases the noise power by a factor of two. The Cramér-Rao bound on the accuracy of time-of-arrival measurements shows that capacity increases directly with the square of the bandwidth used for such measurements.[7] But, Pinpoint claims that capacity increases with the cube of the bandwidth. I believe that claim is incorrect.

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[7] See "Statistical Theory of Passive Location Systems," Don J. Torrieri, IEEE Transactions on Aerospace and Electronc Systems, March, 1984.

23. In its Opposition, Pinpoint also states that the Teletrac forward link transmitters are authorized to operate at powers as high as1,000 watts and that therefore the Teletrac system must have similar interference characteristics as the Pinpoint system with its 484 watt fixed transmitters and 40 watt mobile transmitters. It should be noted that the high-power Teletrac transmissions are narrowband transmission using traditional FM technology. The interfering effects of a single narrowband intervening signal at a known frequency can be alleviated at nearby wideband spread-spectrum receivers through the use of narrowband filters, noise cancelers or skip channel techniques in frequency hopping/spread spectrum systems. No comparable techniques exist to remove the interfering effects of direct sequence spread- spectrum signals such as the Pinpoint signal that is spread over the AVM band. The 1,000 watt narrowband signal and the 500 watt wideband signal have vastly different interference characteristics. In particular, the narrowband signal generates far more severe interference into another narrowband system operation on the same frequency but is much more easily countered by a wideband systems.

V. CONCLUSION

24. While spectrum sharing is desirable in many circumstances, it requires significant and complex Commission regulation to specify the technical standards and sharing rules or etiquettes that ensure efficient spectrum use in the shared environment. The Commission's interim rules for AVM systems do not contain such sharing rules and do not specify such standards. Furthermore, at the time the rules were adopted, the Commission clearly contemplated only one AVM system per band segment in each service area. Given the combination of wide technical flexibility permitted WBPR AVM systems under the Commission's interim AVM rules and the need for compatible systems (or at least systems capable of being operated in a coordinated fashion) to accommodate

sharing, I conclude that attempts to share WBPR AVM spectrum in the same area are problematic and run a high risk of creating intolerable interference.

Charles L. Jackson

DISTRICT OF COLUMBIA: ss

Subscribed and sworn to before me
this 6th day of April, 1993.

Notary Public

My commission expires: My Commission Expires July 14, 1997

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C.

AFFIDAVIT OF JOHN L. PIECHOTA

State of California)
) ss
County of Los Angeles)

JOHN L. PIECHOTA being duly sworn, deposes and says:

1. I am Manager of Engineering Support for PacTel Teletrac ("Teletrac"). In this capacity, I am responsible for coordinating spectrum issues with the Commission. I am also responsible for data communications, corporate networks, and change control board and configuration management. In my previous positions with Teletrac as Spectrum Research Engineer and Design Engineer, I was similarly responsible for spectrum quality and data communications, including the coordination of interference issues. I have been employed by Teletrac since February 1991.

2. My educational background includes a B.S. in Finance, Real Estate and Data Processing with a minor in Electronics Engineering, which I received from the California State Polytechnic University at Pomona in 1975. I subsequently did graduate work there in data processing. During the past two years, I have been pursuing additional graduate studies at the George Washington University in spread spectrum communications and radio frequency management.

3. In my work with Teletrac, I have become knowledgeable concerning Teletrac's wideband pulse-ranging Automatic Vehicle Monitoring ("AVM") systems operating in the 904-912 MHz band. Teletrac's AVM systems provide life/safety services to various state

and federal agencies, including police and fire departments, hospitals, for use with ambulances, and other vehicles so that vehicle locations can be tracked on a computerized map. Currently, Teletrac systems are operating in Los Angeles, Chicago, Detroit, Dallas, Miami and Houston. Teletrac's AVM systems operate in a segment of the Industrial, Scientific and Medical ("ISM") band, and Teletrac's systems are designed to avoid interference with government radio location and ISM operations.

4. Teletrac's AVM systems are experiencing interference from systems operated or constructed by AMTECH Corporation. For example, Teletrac's AVM systems began operation in the Los Angeles area in January, 1991. Shortly thereafter, Teletrac began experiencing interference but was unable to pinpoint the source. In September, 1991, Teletrac was able to determine that its systems were experiencing interference from AMTECH's systems at the Los Angeles International and Orange County/John Wayne Airports. At that time, I contacted AMTECH's Systems Engineer, Mr. Tim Gallagher, to discuss the problem, and he advised me that he would obtain cost estimates for eliminating the harmful interference at the Los Angeles International and Orange County Airports. In mid-October, 1991, Mr. Gallagher said he was "still working on it." On November 12, 1991, Mr. Gallagher informed me that he had been promoted to a marketing position and that a new engineer would be assigned to handle Teletrac's interference concerns. Throughout this time, AMTECH's interference with Teletrac's systems continued.

5. After many telephone calls, on November 18, 1991, I was finally able to speak with the new engineer, Mr. Rand Brown. Mr. Brown informed me that a Mr. George Best, the Director of Field Services for AMTECH in Dallas, was being assigned the task of determining the cost of changing AMTECH's frequency in the Los Angeles area. In a

December 11, 1992, telephone conversation, Mr. Best stated that future AMTECH systems would not be designed or installed using the interfering frequencies at Burbank, Ontario or

Worth area are we were already experiencing in the Los Angeles area. I spoke with Mr. Best again on December 11, 1991, who said that AMTECH would not use the interfering frequencies in the Dallas/Fort Worth and Houston areas based on the Los Angeles area experience. However, in July, 1992, Teletrac's Dallas/Fort Worth Area Network Supervisor, Mr. Marvin Fath, reported to me that he had conducted field investigations and found interfering emissions from the Dallas/Fort Worth Airport's AMTECH system seven (7) months after Mr. Best said they would not use these frequencies.

8. After a significant period of negotiations involving the Los Angeles, Orange County and Dallas/Fort Worth service areas, Teletrac has been able to resolve some of these problems. For example, after many months of discussion, and only after Teletrac filed a complaint with the Dallas office of the Commission's Field Operations Bureau, have some of the current problems we experienced with AMTECH tag readers been alleviated.

John L. Piechota

STATE OF CALIFORNIA

ss

COUNTY OF LOS ANGELES

On May 20, 1993, before me, Pamela S. Hotard, Notary Public, personally appeared John L. Piechota, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/~~are~~ subscribed to the within instrument and acknowledged to me that he/~~she/they~~ executed the same in his/~~her/their~~ authorized capacity(~~ies~~), and that by his/~~her/their~~ signature(s) on the instrument

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TELECOMMUNICATIONS ENGINEER
CHARLES P. TURNER

*NOT ADMITTED IN D.C.
†RESIDENT BRUSSELS

WRITER'S DIRECT DIAL NUMBER

November 12, 1992

(202) 434-4210

VIA FEDERAL EXPRESS

Mr. James D. Wells, EIC
Federal Communications Commission
9330 LBJ Freeway
Room 1170
Dallas, Texas 75243-3429

Re: Interference Complaint

Dear Mr. Wells:

By letter dated October 30, 1992, Amtech Corporation ("Amtech") has purported to respond to the interference complaint reluctantly filed by PacTel Teletrac ("Teletrac") on October 20, 1992. For more than a year, Teletrac has sought an informal resolution of the problems Teletrac has repeatedly encountered with Amtech tag readers. Amtech has avoided any such resolution and, through the Office of its General Counsel, terminated discussions between Amtech and Teletrac. Indeed, Amtech has gone so far as to threaten senseless litigation against Teletrac.

The Dallas-Fort Worth Airport, one of the Amtech users in Dallas affecting Teletrac's system -- which apparently was never informed by Amtech of the problems caused by Amtech tag readers --has advised Teletrac that it is willing to cooperate in eliminating the problem. As a result, communications have been reopened and Teletrac expects to meet with representatives of Amtech once again on November 17 in an effort to reach some resolution of the problems in Dallas and elsewhere. Should those meetings prove successful, there would be no need for the Commission to utilize its scarce resources with regard to Amtech's Dallas interference.

Despite Teletrac's hope that this dispute can now be resolved in a businesslike manner, the Amtech October 30 filing

does contain a number of assertions which are simply untrue or which totally misrepresent the facts.1/ It would be impossible for Teletrac to address all of Amtech's claims without submitting

the readers must be contained within the 5 kHz bandwidth. Amtech's tag readers, therefore, use hundreds of times less bandwidth than the 8 MHz required to qualify as wideband under the Commission's rules. 47 C.F.R. 90.239(c). Thus, Amtech's own description of its operations does not appear to accord with its licenses and should result in an immediate shutdown of Amtech tag readers if they are operating outside the license parameters.5/

"Grandfathering" Narrowband Systems

The FCC's interim AVM rules -- issued in 1974 and never revised -- permit only wideband pulse-ranging AVM systems in the 904-912 and 918-926 MHz bands. Teletrac contends, and we believe

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4/ (...continued)
5 kHz using a non-modulated wave. The frequencies designated include 904, 905, 907, 909, 910, 912, 918, 920, 922, 924, 925, and 926 MHz. Other Amtech licenses specify 20 kHz bandwidth emissions. Regardless of whether Amtech's Dallas tag readers are licensed for 5 kHz or 20 kHz emissions, however, Amtech clearly operates narrowband tag readers.

5/ Amtech also now claims that it is an "unconventional pulsed pseudo doppler radar system." (Amtech October 30 letter at 11, n.30.) Teletrac finds no indication either in the Commission's interim rules or in the 1974 Report and Order that such a technology is permissible for use in this frequency band. Moreover, while the laws of physics insure that the signals returning to tag readers will always contain some doppler shift, in a typical tag reading environment (where the vehicle or container passes directly below or beside the tag reader) the radial component is zero and there is no doppler signal. We have seen no Amtech technical literature that mentions processing of doppler information derived from tag echoes. Section 90.239 explicitly limits the permissible modulation methods to frequency modulation (F1D, F2D, F3E), phase modulation (G1D, G2D and G3E) and sequences of unmodulated pulses (P0N). The Amtech reader emits an unmodulated continuous wave (emission designator N0N) and, as we understand it, the tag sends back an amplitude modulated signal (emission designator A1D or possibly K1D if the tag signal is pulsed). Such emission designators are not permissible for AVM systems under 47 C.F.R. § 90.239(b).

Amtech's own spectrum analyses provided to the Commission staff clearly demonstrates,[6/] that the Amtech system is in fact narrowband. It simply does not belong in the wideband allocation.

Thus, in a Petition for Rulemaking filed by Teletrac some months ago, Teletrac suggested that future tag reader licenses be awarded in other bands that have been set aside for narrowband uses. Teletrac also recommended that the present, improperly-licensed narrowband tag readers be grandfathered to minimize the cost to Amtech and its users. Obviously, any proposed grandfathering was not intended to give Amtech or other narrowband systems unbridled discretion to interfere with and wreck the operations of properly licensed wideband systems such as Teletrac. Indeed, if Amtech's position is taken literally, it means Teletrac should insist that all narrowband systems move from the wideband-designated frequencies entirely.

Notice of Actual Interference

Amtech attempts to justify its failure to deal with this interference problem when it was first raised by Teletrac over one year ago by claiming that the problem was only "potential" and, therefore, Amtech chose not to act. (Amtech October 30 letter at 5.) However, it is obvious that the best evidence of mutual cooperation would have been for Amtech to deal with that known "potential" problem before it became, predictably, an actual problem.

At the time Teletrac contacted Amtech about the Dallas problem, Amtech engineers and management were already well aware of the actual interference to Teletrac created by Amtech's tag readers in Los Angeles and Orange County. In fact, the Director of Field Services for Amtech in Dallas coordinated the engineering modifications for the Los Angeles and Orange County Amtech systems and indicated to Teletrac personnel that the Dallas-Fort Worth Amtech systems would be designed to avoid the interference experienced in California. Amtech cannot now claim that it had no basis for acting to correct the interference before it occurred.

6/ See "Spectrum Requirements for the Amtech Electronic Identification System," dated June 22, 1992, submitted to the Private Radio Bureau by Amtech.

Conclusion

Teletrac will keep the Commission apprised of progress on the negotiations to resolve the interference problem and requests that your office stay action on the complaint until December 1, 1992. If satisfactory progress on the negotiations is not underway by December 1st, Teletrac will submit a supplemental filing.

You attention to this matter is appreciated.

Sincerely,

John B Richards

John B. Richards

Attachments

cc: Mr. Richard M. Smith
Chief, Field Operations Bureau

Mr. Ralph Haller
Chief, Private Radio Bureau

Mr. Roy Kolly
Assistant Chief, Enforcement Division
Field Operations Bureau

Mr. Ronald A. Woessner
General Counsel, Amtech

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[redacted]

close proximity. These types of signpost, proximity sensing
systems typically are used for automatic toll collection and

anticipated from the tag readers being installed at the Airport.[4/] Teletrac had experienced actual interference from Amtech tag readers in Los Angeles, and it took months for Amtech to respond to that problem. In the interim, Teletrac suffered degradation of its signal in Los Angeles, harming Teletrac's customers and Teletrac's business. Accordingly, in Dallas, Teletrac raised the interference problem with Amtech before the Dallas Teletrac system began operating to avoid service

Under the Commission's rules, all applicants and licensees in the Private Land Mobile Radio Services are required to cooperate in the selection and use of frequencies in order to reduce interference and to make the most effective use of the authorized facilities. 47 C.F.R. 90.173(b). All licensees of stations suffering or causing harmful interference are expected to cooperate and resolve interference problems by mutually satisfactory arrangements. Id. Moreover, secondary operations such as the Airport's narrowband "tag reader" systems are expressly prohibited from causing interference to operations such as Teletrac's wideband AVM systems, which are authorized on a primary basis. 47 C.F.R. 90.7.

In light of the refusal of Amtech representatives and the Dallas Airport authorities to take corrective action to eliminate this interference, the intervention of the local Field Operations Bureau Office is required. Your prompt action in resolving this pressing matter would be very much appreciated.

Should you have any questions or require any further information, by all means please feel free to contact the undersigned. Teletrac would be pleased to assist in any way possible.

Sincerely,

John B. Richards

Attachment

cc: Richard M. Smith
Chief, Field Operations Bureau

Ralph A. Haller
Chief, Private Radio Bureau

Roy E. Kolly
Asst. Chief, Enforcement Division, FOB

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DFW Airport Board

CERTIFICATE OF SERVICE

I hereby certify that on this 21st day of May, 1993, a copy of the foregoing NORTH AMERICAN TELETRAC and LOCATION TECHNOLOGIES, INC.'S APPLICATION FOR FREEZE was served by first class United States mail, postage prepaid on the following parties:

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